Importance of colloidal dispersion in pharmacy

Health & Medicine

Importance of colloidal dispersion in pharmacy Pharmaceutical Applications of colloids: Colloids are extensively used for modifying the properties of pharmaceutical agents. The most common property that is affected is the solubility of a drug . However, colloidal forms of many drugs exhibits substantially different properties when compared with traditional forms of these drugs. Certain medicinals have been found to possess unusual or increased therapeutic properties when formulated in the colloidal state.

Another important pharmaceutical application of colloid is their use as drug delivery system. The most often used colloid type drug delivery systems include hydrogels, microspheres, microemulsions, liposomes, micelles, nanoparticles and nanocrystals. Here we mention the main characteristics of each colloidal delivery system. Hydrogels: Hydrogel is a colloidal gel in which water is the dispersion medium. It (also called aquagel) is a network of polymer chains that are hydrophilic, sometimes found as a colloidal gel in which water is the dispersion medium.

Hydrogels are highly absorbent (they can contain over 99% water) natural or synthetic polymers. Hydrogels also possess a degree of flexibility very similar to natural tissue, due to their significant water content. These hydrogels have the ability to sense changes of pH, temperature, or the concentration of metabolite and release their load as result of such a change Natural and synthetic hydrogels are used for wound healing, as scaffolds in tissue engineering, and as sustained- release delivery systems.

When used as scaffolds for tissue engineering, hydrogels may contain human cells to stimulate tissue repair, since they are loaded with pharmaceutical ingredients, hydrogels provide a sustained drug release. Light-sensitive,

pressure- responsive, and electro-sensitive hydrogels also have the potential to be used in drug delivery. Environmentally sensitive hydrogels include slow response time, limited biocompatibility, and biodegradability. Hydrogel used as sustained-release drug delivery systems. it provide absorption, desloughing and debriding capacities of necrotics and fibrotic tissue. ydrogels that are responsive to specific molecules, such as glucose or antigens can be used as biosensors, as well as in DDS. Also used in disposable diapers where they " capture" urine, or in sanitary napkins, contact lenses (silicone hydrogels, polyacrylamides). Medical electrodes using hydrogels composed of cross-linked polymers (polyethylene oxide, polyAMPS and polyvinylpyrrolidone). hydrogel used as water gel explosives, rectal drug delivery and diagnosis. Other, less common uses include, breast implants, granules for holding soil moisture in arid areas, dressings for healing of burn or other hard-to-heal wounds.

Wound gels are excellent for helping to create or maintain a moistenvironment, reservoirs in topical drug delivery; particularly ionic drugs, delivered by iontophoresis (see ion exchange resin), Common ingredients are e. g. polyvinyl alcohol, sodium polyacrylate, acrylate polymers and copolymers with an abundance of hydrophilic groups. Natural hydrogel materials are being investigated for tissue engineering; these materials include agarose, methylcellulose, hyaluronan, and other naturally derived polymers. However if the achievements of the past can be extrapolated into the future, it is likely that responsive hydrogels with a wide array of desirable properties will be forthcoming. Microparticles: Microparticles are small loaded microspheres of natural or synthetic

polymers. Microparticles was initially developed as carriers for vaccines and anti-cancer drugs. More recently, novel properties of Microparticles have been developed to increase the efficiency of drug delivery and improve release profiles and drug targeting.

Several investigations have focused on the development of methods of reducing the uptake of the nanoparticles by the cells of the reticuloendothelial system and enhance their uptake by the targeted cells. Functional surface coatings of non-biodegradable carboxylated polystyrene or biodegradable poly (D, L- lactide-co-glycolide) microspheres with poly(L-lysine)-g-poly (ethylene glycol) (PLL-g-PEG) were investigated in attempts to shield them from nonspecific phagocytosis and to allow ligand- specific interactions via molecular recognisition.

It was found that coatings of PLL-g-PEG- ligand conjugates provided for the specific targeting of microspheres to human blood- derived macrophages and dendritic cells while reducing non- specific phagocytosis. Microparticles can also be used to facilitate nontraditional routes of drug administration. It was found that Microparticles can be used to improve immunization using the mucosal route of administration of therapeutics. It was found in this study that mucosal route of administration of therapeutics can translocate to tissues in the systemic compartment of the immune system and provoke immunological reactions. Micro & Nano-Emulsions:

Microemulsions are excellent candidates as potential drug delivery systems because of their improved drug solubilization, long shelf life, and ease of preparation and administration. Three distinct Microemulsions- oil external, water external, and middle phase- can be used for drug delivery, depending

upon the type of the dug and the site of action. In contrast to Microparticles, which demonstrate distinct differences between the outer shell and core, microemulsions are usually formed with more or less homogeneous particles. Microemulsions are use for controlled release and targeted delivery of different pharmaceutics agents.

For instance, microemulsions were used to deliver oligonucleotides (small fragments of DNA) specifically to ovarian cancer cells. In contrast to microemulsions, Nanoemulsions consist in very fine oil-in-water dispersions, having droplets diameter smaller than 100 nm. Compared to microemulsions, they are in a meta stable state, and their structure depends on the history of the system. Nanoemulsions are very fragile systems. The nanoemulsions can find applications in skin care due to their good sensorial properties (rapid penetration, merging textures) and their biophysical properties (especially their hydrating power).

Liposomes: Liposomes consist of an outer uni - or multilamellar membrane and an inner liquid core. In most cases liposomes are formed with natural or synthetic phospholipids similar to those in cellular plasma membrane, because of this similarity, liposomes are easily utilized by cells. Liposomes can be loaded by pharmaceutical or other ingredients by two principal ways: Lipophilic substances can be associated with liposomal membrane, and hydrophilic substances can be dissolved in the inner liquid core of liposomes.

To decrease uptake by the cells of the reticuloendothelial system and/or enhance their uptake by the targeted cells, the membrane of liposomes can be modified by polymeric chains and/or targeting moieties or antibodies specific to the targeted cells, because they are relatively easy to prepare,

biodegradable, and non- toxic, liposomes have found numerous applications as drug delivery systems. Liposomes are of colloidal dimensions and are preferentially taken up by the liver and spleen. Hence, principle of colloids is also used in targeted drug delivery system. Liposomes are used for drug delivery due to their unique properties.

A liposome encapsulates a region on aqueous solution inside a hydrophobic membrane; dissolved hydrophilic solutes cannot readily pass through the lipids. Hydrophobic chemicals can be dissolved into the membrane, and in this way liposome can carry both hydrophobic molecules and hydrophilic molecules. To deliver the molecules to sites of action, the lipid bilayer can fuse with other bilayers such as the cell membrane, thus delivering the liposome contents. By making liposomes in a solution of DNA or drugs (which would normally be unable to diffuse through the membrane) they can be (indiscriminately) delivered past the lipid bilayer.

There are three types of liposomes - MLV (multilamellar vesicles) SUV (Small Unilamellar Vesicles) and LUV (Large Unilamellar Vesicles). These are used to deliver different types of drugs. Liposomes are used as models for artificial cells. Liposomes can also be designed to deliver drugs in other ways. Liposomes that contain low (or high) pH can be constructed such that dissolved aqueous drugs will be charged in solution (i. e. , the pH is outside the drug's pI range). As the pH naturally neutralizes within the liposome (protons can pass through some membranes), the drug will also be neutralized, allowing it to freely pass through a membrane.

These liposomes work to deliver drug by diffusion rather than by direct cell fusion. Another strategy for liposome drug delivery is to target endocytosis

events. Liposomes can be made in a particular size range that makes them viable targets for natural macrophage phagocytosis. These liposomes may be digested while in the macrophage's phagosome, thus releasing its drug. Liposomes can also be decorated with opsonins and ligands to activate endocytosis in other cell types. The use of liposomes for transformation or transfection of DNA into a host cell is known as lipofection.

In addition to gene and drug delivery applications, liposomes can be used as carriers for the delivery of dyes to textiles, pesticides to plants, enzymes and nutritional supplements to foods, and cosmetics to the skin. Another interesting property of liposomes is their natural ability to target cancer. The endothelial wall of all healthy human blood vessels is encapsulated by endothelial cells that are bound together by tight junctions. These tight junctions stop any large particles in the blood from leaking out of the vessel.

Tumour vessels do not contain the same level of seal between cells and are diagnostically leaky. This ability is known as the Enhanced Permeability and Retention effect. Liposomes of certain sizes, typically less than 200 nm, can rapidly enter tumour sites from the blood, but are kept in the bloodstream by the endothelial wall in healthy tissue vasculature. Anti-cancer drugs such as Doxorubicin (Doxil), Camptothecin and Daunorubicin (Daunoxome) are currently being marketed in liposome delivery systems. Micelles: Micelles are similar to liposomes but they do not have an inner liquid compartment.

Therefore they can be used as water- soluble biocompatible micro containers for the delivery of poorly soluble hydrophobic pharmaceuticals. Similar to liposomes their surface can be modified with antibodies (immunomicelles) or other targeting moieties providing the ability of micelles to specifically

interact with their antigens. One type of micelles pluronic block copolymers, are recognized as pharmaceutical excipients listed in the U. S and British Pharmacopoeia. They have been extensively used in a variety of pharmaceutical formulations including delivery of low molecular mass drugs, polypeptides, and DNA.

Furthermore, Pluronic block copolymers are versatile molecules that can be used as structural elements of polycation- based gene delivery system. Nanoparticles: Nanocapsules are sub-microscopic colloidal carrier systems composed of an oily or an aqueous core surrounded by a thin polymer membrane. Nanoparticles are the colloidal particulate systems with size ranging between 1-1000 nm. Based on the arrangement of drug and polymer matrix, nanoparticles can be classified into two types: nanospheres and nanocapsules . In nanospheres, rugs are either adsorbed or entrapped inside the polymeric matrix. In nanocapsules, drugs are confined to the inner liquid core while the external surface of nanoparticles is covered by the polymeric membrane. polymeric nanoparticles have gained considerable attention as potential drug delivery systems due to its targetability to particular organ/tissue and ability to deliver protein and peptide via oral route. Nanoparticles for drug delivery are generally made up of biocompatible and biodegradable polymers obtained from either natural or synthetic source.

Natural polymers include chitosan, albumin, rosin, sodium alginate and gelatin while, synthetic polymers include poly (lactic acid) PLA, poly (D, L-glycolide), poly (lactide-co-glycolide), poly (caprolactones) (PCL) and poly (cyanoacrylates). The kinetics of drug release from nanoparticles depends on the strength of hydrophobic interactions between the polymer and drug and

polymer degradation rate. The uptake and distribution of nanoparticles depend on its size. Nanoparticles of size ~10 nm are utilized for extended circulation, while ~100 and ~200 nm particles are utilized for passive targeting and intracellular drug delivery respectively.

Though nanoparticles have many advantages over other conventional drug delivery systems certain properties like surface hydrophobicity and surface charge needs to be altered so as to increase the uptake of nanoparticles into cells. This can be done by judiciously manipulating the use of polymers. Coating the nanoparticles with chitosan which is positively charged significantly enhances the uptake and modulates the drug efflux of anticancer agents. Moreover, attachment of poly (ethylene glycol) moieties to the surface of nanoparticles increases the hydrophilicity and hence decreases the uptake by macrophages.

Recent studies by Yoncheva et al. concluded that amino-pegylated poly (methyl vinyl ether-co-maleic anhydride) nanoparticles were able to cross the cell membrane of the absorptive enterocytes in a better way. Nanoparticles are characterized by a variety of techniques such as dynamic light scattering (DLS), electron microscopy (TEM or SEM), atomic force microscopy (AFM), Fourier transform infrared spectroscopy (FTIR), x-ray photoelectron spectroscopy (XPS), powder X-ray diffraction (XRD), matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF), and magnetic resonance (NMR).

Two technologies can be used to develop such Nanocapsules: the interfacial polymerization of a monomer or the interfacial nano deposition of a performed polymer. Solid lipid nanoparticles are developed at the beginning

of the 1990’s as an alternative carrier system to emulsions, liposomes, and polymeric nanoparticles. They are used in particular in cosmetic and pharmaceutical formulations. A novel nano-particle based drug carrier for photodynamic therapy has been developed.

This carrier can provide stable aqueous dispersion of hydrophobicphoto-sensitizers; yet preserve the key step of photo generation of singlet oxygen, necessary for photodynamic action. Nanoparticles have also found applications as nonviral gene delivery systems. Advantages of nanoparticles a) Longer shelf-stability b) High carrier capacity c) Ability to incorporate hydrophilic and hydrophobic drug molecules d) Can be administered via different routes e) Longer clearance time f) Ability to sustain the release of drug) Can be utilized for imaging studies h) Increase the bioavailability of drugs i) Targeted delivery of drugs at cellular and nuclear level j) Development of new medicines which are safer k) Prevent the multi-drug resistance mediated efflux of chemotherapeutic agents l) Product life extension Nanocrystals: Inorganic crystals that interface with biologic systems have recently attracted widespread interest in biology and medicine. To explore the feasibility of in vivo targeting by using semiconductor quantum dots (qdots), which are small (